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ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA
A COMPREHENSIVE SUMMARY OF PROJECT TREND.(U)
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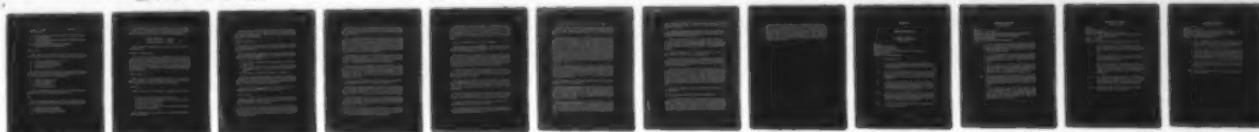
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accumulated. Accordingly, four classes have been distinguished based on the predominant depths of soil:

- d: predominantly deep soils (more than 60 cm), sometimes with dense concretions at less than 60 cm.
- m: predominantly medium deep soils (30-60 cm), frequently with dense concretions at less than 60 cm.
- m/s: predominantly medium deep and shallow soils mixed.
- s: predominantly shallow soils (less than 30 cm).

Surface stoniness

Surface stoniness has been divided into four classes, according to the extent to which the surface of the ground is covered by boulders, stones, and rock outcrops:

- 0: no or very few boulders and/or rock outcrops.
- 1: few boulders and/or rock outcrops.
- 2: many boulders and/or rock outcrops.
- 3: bouldery and/or rocky land.

An estimate was made of the percentage of the surface of the ground covered by boulders, etc., in these classes by measuring some representative sites. In this way it was estimated that the classes covered the following limits:

- 0: less than 0.02 % boulders, etc.
- 1: 0.02 to 0.2 % boulders, etc.
- 2: 0.2 to 10 % boulders, etc.
- 3: more than 10 % boulders, etc.

Again considerable variation occurs within each area and mapping units have been designated on the basis of the predominant class in the area.

Slope

Since very little flat land (slope less than 2 %) occurs in the survey area, this slope class has not been indicated separately. Three classes were distinguished as follows:

- A: slope from 0-10 % (flat to sloping).
- B: slope from 10-20 % (moderately steep).
- C: slope more than 20 % (steep to very steep).

For most observation sites, slopes were measured. However, the cartographic delineation of the slope class areas is based on the topographic map, where the distance between the 10-meter contour intervals was systematically measured and interpreted in terms of the above-mentioned slope classes (measured on 1:10,000 scale map):

Distance more than 1 cm = A-slope
Distance from 0.5-1 cm = B-slope
Distance less than 0.5 cm = C-slope

Simplification had to be applied because not all minor incidents of slopes can be indicated on the map.

Interrelation of mapping elements

In the survey area, these elements are interrelated, and not all possible combinations occur. Soils of the d-class are situated on flatter land (A- or B-slope) and have 0 stoniness; m-soils occur on all slopes, but their stoniness does not exceed 1; m/s-soils also occur on all slopes, but their stoniness is either 1 or 2; and s-soils on C-slopes all have stoniness 3. (It is noted that s-soils on slopes A and B occur only in areas with open dipterocarp forest.) These limitations reduce the possible 48 combinations to an occurrence of only 20.

Colluvial foot slopes

Where a complex of various morphometric soil units occurs on colluvial foot slopes, this is marked CC. This unit has been added because of the occurrence of many different morphometric units within short distances at these locations.

Other elements

Special characteristics, of incidental importance and applicable to some soils only, are:

- M: mottled and grey color throughout; poorly drained soils.
- m: weak mottles in the subsoil; moderately well to imperfectly drained soils.
- y: hue of the soil is 7.5 YR or more yellow.
- r: hue of the soil is 5 YR or more red.
- C: presence of a layer with abundant concretions at less than 60 cm, with a minimal layer thickness of 10 cm.

These elements imply some characteristics occur. (Element M has been also included in the detailed map.)

All special characteristics of the morphometric symbol are written below the bar. Thus d0A/ym is a deep soil with little surface stoniness, on flat to gentle slope, with a yellow, somewhat mottled subsoil (i.e., moderately well drained Red-Yellow Podzolic soil on materials derived from shales).

Great soil groups and soil series

The majority of the soils belongs to the Red-Yellow Podzolic great soil group (tropustults, according to the 1967 revision of the 7th Approximation). The situation can be summarized as follows:

Red-Yellow Podzolic soils (tropustults). This is the dominant great soil group of the area, occurring in all topographic positions on materials derived from both sandstone and shale. Soil series included are:

Ky: Khao Yai series, covering the deep soils (d0A and d0B), occurring in the dry-evergreen forest.

M1: Muak Lek series, covering the deeper soils on shale-derived material (d0A/my), differing from the Ky series in the yellow colour and presence of mottles.

Ty: Tha Yang series, covering all soils with a stoniness of 1 or higher

Reddish Brown Lateritic soils (rhodustults). Some of the soils may belong to this great soil group, i.e., those on somewhat richer shales. However, their occurrence is incidental, and the soils observed appear to be transitional to the Red-Yellow Podzolic soils. The closest series equivalent would be Trat series (Td).

Low-Humic Gley soils (tropaquults). These soils were found in a few poorly drained depressions. No series equivalent can be given at this time.

Soil series descriptions

Khao Yai series (Ky). These are the deep soils in the morphometric units d0A and d0B, and occur only on shallow slopes in the dry-evergreen forest where the flatness and vegetation prevent erosion of the top soil.

In the forest, the soil is covered by 2-3 cm of leaf litter. The A horizon has a thickness of 20 cm in the lower sites and 10 cm in the higher sites, and is differentiated into a humiferous A₁ (1-4 cm thick) and a paler, leached A₂. The Bt horizon usually contains concretions as the lower levels and may change to a B/C horizon before a depth of 100 cm is reached.

The texture does not vary much throughout the area. In the A horizon the texture varies between fine sandy loam and loam. The B horizon consists of sandy clay loam with sandy clay loam to clay at the deeper levels. Weak and distinct clay skins are found in the B horizon.

The color varies and depends largely on the quantity of iron in the parent material. Normally, the color of A₁ is brown (7.5 YR 4/4), but it varies between dark reddish brown (5 YR 3/4) and dark yellowish brown (10 YR 4/4). The A₂ has the same hue as A₁, but with a higher value and chroma, the usual color being strong brown (7.5 YR 5/7). The B horizon has a redder hue than the A horizon, the usual color being yellowish red (5 YR 4/6-8). Soils with deviating colors are marked on Map 2, and the others conform to the colors described here.

Soil pH is slightly acid in the topsoil to acid in the subsoil; it varies in the horizons between the following limiting values: A₁ 5.5-6.5, A₂ 5.0-5.5, B₁ 4.5-5.0. The only exceptions are recently burnt clearings where the upper few centimeters of the top soil are neutral or even slightly alkaline. Soils of the series are well drained.

Concretions may be found at depths of more than 60 cm. This term covers small amounts of sandstone gravel and shale fragments of the same size and color as well as true concretions. The latter are rounded and red, with an average diameter of 1 cm but sometimes with pieces up to 4 cm diameter, and consist of hard, dark red, concentric lateritic layers, usually with a core of red sandstone (in which case they are called pseudo-lateritic concretions).

An example of a red member of the Ky series, which is possibly a transition to the Trat series (Reddish Brown Lateritic soil), is described in Appendix D.

Khao Yai series, shallow phase (Ky-sh). Mediumly deep soils m0A and m0B belong to this series, which differs from the Ky series only in the depth of soil (between 30 and 60 cm) and/or the occurrence of concretions within the first 60 cm. All other properties such as color, texture, etc. are the same as those of the Ky series.

Muak Lek series (Ml). This series covers the soils of the morphometric group d0A/my. They consist of colluvium and residuum derived from shales and sandstone, and occur only occasionally. The major differences from the Ky series are the yellow color and the presence of mottles.

The genetic soils horizons are about the same thickness as in the Ky soils of the lower sites, i.e., with an A horizon of about 20 cm. The texture is somewhat more clayey than that of Ky soils and distinct clay coatings occur in the B horizon. Weak mottles usually occur in the subsoil as a result of imperfect drainage.

The color of the A₁ horizon varies between very dark greyish brown (10 YR 3/2) and dark yellowish brown (10 YR 4/4). The A₂ has higher values and chromas and is yellowish brown (10 YR 5/4-7). The B horizon has the same or a redder color and varies between yellowish brown (10 YR 5/4-8) and strong brown (7.5 YR 5/6-8). Soil pH is slightly acid in the topsoil and acid in the subsoil. Sometimes concretions are present in the lower subsoil, most of them being more or less weathered shale fragments.

An example of the Muak Lek series is described in Appendix D.

Muak Lek and Khao Yai association (Ml/Ky). Soils belonging to this association may have the properties of Ky or Ml or both, and include the morphometric groups d0A/my, d0A/y, d0A, d0B/my, d0B/y, and d0B.

They probably arise from weathering of a mixed parent material. Shales are intercalated in the sandstone as layers and lenses, and weathering can produce patches with Ky properties, with Ml properties, and, where a thin shale layer existed, with a combination of both. Furthermore, heavy rainfall causes transportation of material from the topsoil and this may result in the deposition of topsoil derived from shale on a subsoil with many pseudo-lateritic concretions and pieces of sandstone.

A particular characteristic of the Ml/Ky association in the west (squares B2, B3 and C2) is the unusual absence of sandstone boulders on a B slope in dry evergreen forest, which elsewhere has a stoniness of 1. This appears to be associated with a fairly high percentage of shales in this region.

Tha Yang series (Ty). This series includes all soils of stoniness of 1 and higher. It has been divided into two phases to separate the soils of the escarpment from the others. It differs from the Ky series in the shallowness of the soil, the content of boulders and stones at the surface and in the soil, and the occurrence of concretions at shallow depths.

The genetic soil horizons of the topsoil have about the same thickness as those of the Ky series. The subsoil changes to a B/C horizon before a depth of 100 cm is reached in the dry evergreen forest and to a C horizon in the dry dipterocarp forest.

Textures are loamy in the surface layer (sandy loam or loam) and clayey in the subsoil (sandy clay loam, clay loam, sandy clay, or clay).

The colors correspond with the colors of the Ky series, although soils with a yellower hue than the average seldom occur. The colors in the profiles of Appendix A and B represent the average colors for the Ty series.

Soil pH is slightly acid near the surface and becomes acid in the subsoil.

Soils of the Ty series are well drained. Pseudolateritic concretions and sandstone gravel start at different depths, but usually before 20 cm, and increase in size and number with depth. Sandstone boulders are found in the surface and throughout the profile.

Morphological difference between Ty in the dry evergreen forest and the dry dipterocarp forest are not very obvious. In the dipterocarp forest, soils are generally shallower and more stony, although equally shallow and stony soils exist in the dry evergreen forest. The major difference is in surface stoniness. In the dipterocarp forest, most of the stones are more or less on the surface of the soil; whereas in the dry evergreen forest, stones and rocks are mostly embedded in the soil mass. It is probable that continuous sheet erosion is in progress in the dipterocarp forest with its incomplete ground cover, forming an uncovered stone pavement, and the shallowness of the soil in the dipterocarp forest may thus be self-perpetuating. The impression is formed also that the surface soil of the dipterocarp forest is somewhat sandier and has a poorer humus type than the surface soil of the dry evergreen forest. Further study of this is required.

The basic ecological reasons for the existence of the two very distinct forest types are not yet clear. Our present thinking is that the soil materials in the area of the dry evergreen forest, which is found generally on the higher levels of the terrain, are mostly mixed with materials derived from shales, whereas the lower soils under the dipterocarp forest are mostly from more or less pure sandstone. A mineralogical comparison of the soil materials is needed.

Profile description of Ty soils, one under dipterocarp forest and the other under dry evergreen forest, are given in Appendix D.

Tha Yang series, sloping phase (Ty-sl). This phase has been introduced to separate the soils of the upper slope of the escarpment, and it includes soils of group s3C. In this region, nearly perpendicular slopes occur at places, with large rock outcrops alternating with steep slopes. The slope is covered with sandstone rock outcrops, boulders, and stones. Predominantly shallow soils occur, although deep soils form in places where soil material can accumulate.

Tha Yang series, colluvial phase (Ty-c). The soils of this phase occur on the lower, less steep slopes of the escarpment and on the stream-cut terraces along the escarpment. This phase has been marked CC (colluvial complex) in the morphometric legend. All soil depths occur in large and small patches, and there are fast changes in stoniness, patches almost without stones and with deep soils changing within a few

meters to patches with stoniness 3. The boundary between Ty-sl and Ty-c has been obtained by airphoto interpretation, and lies on the transition between steep and moderately steep slopes.

Low-Humic Gley soils (LHG). These soils are found in a few poorly drained depressions and are formed on colluvium and residuum of sandstone and shale. They are in group d0A/My of the morphometric legend.

All LHG soils are found in clearings. A remarkable feature of the LHG spot at the center of square H7 is the absence of sugarcane, which is amongst the usual secondary vegetation of clearings after shifting cultivation. Here the groundwater table is too high to permit the growth of sugarcane, and the only vegetation subsisting is alang alang.

The genetic soil horizons are: A₁ 0-3 cm, A_{2g} 3-13 cm, B_{1t_g} 13-25 cm, B_{2t_g} deeper than 25 cm, and eventually B_{2t_g/c} deeper than 60 cm.

Texture in the A horizon is sandy loam. The illuvial B horizon has a higher clay content, and textures vary between sandy clay loam and clay loam. Mottling is present throughout the profile, or immediately below the surface, and occurs most frequently along root channels and fissures.

The dominant soil colors all have a hue of 10 YR, whilst the mottles always have redder hues of 7.5 YR or even 5 YR. The A₁ horizon is dark greyish brown (10 YR 4/2) to dark brown (10 YR 3/3), and the A₂ horizon is brown and has a few strong brown (7.5 YR 5/6) mottles. The B horizon is light brownish grey (10 YR 6/2) and has many mottles of the same color as in the A₂. These colors continue unchanged to depths of more than 100 cm, except near the boundary with surrounding soils where colors of weathering sandstone (e.g. 5 YR 3/4) may occur at depths between 60 and 100 cm.

Soil pH is like the Red-Yellow Podzolic soils, slightly acid in the surface soils and acid in the subsoil.

Soils of the survey area as related to soil conditions in other hilly areas

Soil conditions in the survey area are estimated to be fairly representative of general soil conditions in the hilly parts of southeast Asia, and those of Thailand in particular. The dominant great soil group in the survey area is a Red-Yellow Podzolic soil. This great soil group is also the dominant soil in most hilly terrains of southeast Asia, notably on residuum and colluvium from more or less acid rocks, as there are sandstones, conglomerates, sandy shales, siltstones, complex quartzite-phyllite

formations, granites, granitic gneisses, etc. Throughout hilly southeast Asia, the shallow, more or less stony Red-Yellow Podzolic soils dominate strongly, and these shallow soils are amply represented in the survey area. The deeper members occur much less frequently, being confined mainly to peneplained areas, plateaus, and foot-slopes. In this respect, the survey area is quite representative for the central highlands of Thailand, where such plateaus with deeper soils occur quite extensively. In neighboring countries, e.g. South Vietnam, such plateau areas with deeper soils are a common, though minor, feature.

APPENDIX D

PROFILE DESCRIPTIONS

DESCRIPTION OF PROFILE T4 (Map 6, square D4)

Series: Ky

Morphometric symbol: d0A/r

Vegetation: dry-evergreen forest.

Parent material: residuum and colluvium from iron-rich red sandstone.

Drainage: well drained.

Topography: gently undulating plateau.

- | | |
|-------------------|---|
| 0 ₁ | 2 to 0 cm, leaf litter. |
| A ₁ | 0 to 2 cm, dark reddish brown (5 YR 3/4) fine loam; fine moderate crumb; very friable; many fine interstitial pores; many fine roots; clear, smooth boundary; pH 5.5. |
| A ₂ | 2 to 9 cm, reddish brown (5 YR 4/5) fine loam; weak fine subangular blocky; very friable; common fine and very fine tubular and very fine interstitial pores; common medium and thick roots; clear, smooth boundary; pH 5. |
| B ₁ | 9 to 20 cm, red (2.5 YR 4/6) clay loam; moderate to weak fine subangular blocky; friable; weak and patchy clay skins; common fine and very fine tubular and common fine interstitial pores; common medium and thick roots; diffuse, smooth boundary; pH 4.5. |
| B ₂₁ t | 20 to 80 cm, red (2.5 YR 4/6) light clay; moderate fine subangular blocky; friable; distinct and patchy clay skins; common fine and very fine tubular and common very fine interstitial pores; common medium and thick roots; gradual, smooth boundary; pH 4.5. |
| B ₂₂ t | + 80 cm same as B ₂₁ t, but with concretions of 1 cm and less, increasing in size and number with depth. |

DESCRIPTION OF PROFILE T5
(Map 6, square G7)

Series: M1

Morphometric symbol: d0A/my

Vegetation: secondary vegetation after shifting cultivation, *alang alang*, sugarcane.

Parent material: residuum and colluvium from shale and sandstone.

Drainage: imperfectly drained.

Topography: gently rolling on the side of a long slope.

- A₁ 0 to 4 cm, very dark greyish brown (10 YR 3/2) to brown (10 YR 4/3) fine loam; very weak medium and fine crumb; friable; many fine interstitial pores; organic matter poorly incorporated; common fine roots; clear, smooth boundary; pH 6.0.
- A₂ 4 to 17 cm, yellowish brown (10 YR 5/4) silt loam; common fine distinct mottling; moderate to weak fine subangular blocky; friable; common fine tubular pores; common fine roots; clear, smooth boundary; pH 5.5.
- B₂₁t 17 to 38 cm, strong brown (7.5 YR 5/5) clay loam; common fine faint mottling; moderate to strong fine and medium subangular blocky; slightly firm; distinct clay coatings, movement in pores; many fine tubular pores; few fine roots; gradual, smooth boundary; pH 5.0.
- B₂₂t 38 to 62 cm, strong brown (7.5 YR 5/5) clay loam to clay; common, medium faint mottling; moderate to strong fine and medium subangular blocky; slightly sticky, plastic, distinct clay coatings; common fine tubular and interstitial pores; few fine roots; clear, smooth boundary; pH 4.5.
- B₃ + 62 cm, multicolored brownish yellow (10 YR 6/5) and yellowish red (5 YR 5/6) mottled clay; many fine and medium distinct mottles; moderate strong fine and medium subangular blocky; slightly sticky, plastic; distinct clay coatings; many gravels, mostly shale, diameter smaller than 2 cm; few fine roots; pH 4.5.

DESCRIPTION OF PROFILE T1
(Map 6, square 18)

Series: Ty

Morphometric symbol: m1A/c

Vegetation: open dipterocarp forest with sparse grass floor.

Parent material: derived from sandstone, rounded gravels in lower profile, sandstone boulders throughout profile.

Drainage: well drained.

Topography: locally undulating in a rolling landscape, saddle between two knolls.

- A₁ 0 to 3 cm, dark brown (7.5 YR 3/2) loamy sand to sandy loam; weak fine to medium crumb; very friable; many fine interstitial pores; some fine and medium tubular pores; many roots; clear, smooth boundary; pH 5.5.
- A₂ 3 to 8/11 cm, dark brown to brown (7.5 YR 4/3) sandy loam; very weak fine subangular blocky; very friable; many fine tubular pores; many roots; clear, wavy boundary.
- B₁ 8/11 to 24 cm, reddish brown to yellowish red (5 YR 4/5) gravelly sandy clay loam; moderate fine subangular blocky; friable, patchy clay coatings; common fine tubular pores; ± rounded gravels, hard outside, sandstone inside, 3-15 mm diameter; common roots; gradual, smooth boundary; pH 4.5.
- B_{2t} 24 to 40/48 cm, yellowish red (5 YR 4/7), very gravelly (sandy) clay loam; moderate fine subangular blocky; friable to form soil matrix; distinct clay coatings; common fine tubular pores; same gravels as in B₁, but more (> 60%); common roots; broken boundary; pH 4.5.
- B & C + 40/48 cm, reddish yellow (7.5 YR 6/7) weathered sandstone, with yellowish red (5 YR 4/7) Bt material in between.

DESCRIPTION OF PROFILE T2
(Map 6, square H7)

Morphometric symbol: mIB/c

Vegetation: dry-evergreen forest, with a distinct forest litter on the surface.

Parent material: residuum and colluvium from sandstone, surface stoniness 1.

Drainage: well drained, after rains moist to about 60 cm.

Topography: rolling, on side of hill, long slope.

- A₁ 0 to 6 cm, reddish brown to brown (5-7.5 YR 4/3) gravelly, fine sandy loam; strong fine crumb; very friable; many fine and medium interstitial pores; many roots; gradual, smooth boundary; pH 5.5 to 6.
- A₂ 6 to 20 cm, reddish brown to yellowish red (5 YR 4/5) gravelly fine sandy loam; moderate fine crumb; fine subangular blocky; friable; many fine and medium interstitial and tubular pores; many holes (low bulk density); lateritic gravels, \pm rounded, 5-10 mm diameter; also stones and boulders; common roots; gradual, wavy boundary; pH 4.5.
- B₂ ten 40/45 to 75, yellowish red (5 YR 4/6) very gravelly clay loam; structure as before; gravels, stones and boulders as B₁; \pm 60% gravels; clear, broken boundary.
- C & B₂ ten + 75 cm, very gravelly clay loam with many weathering sandstone stones and boulders.